



This document contains the Comprehensive Conservation and Management Plan for Narragansett Bay, December 1992: Introduction, Background: State of the Bay sections: Physiographic Setting, and History and Uses of the Bay

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December 1992

715-01 INTRODUCTION

In establishing the National Estuary Program, the United States Congress recognized the special need to protect an important but endangered resource: our nation's estuaries. Four regional estuary projects were created in 1985, modeled on the Chesapeake Bay Program's multi-state effort to manage watershed-based impacts on the Bay. The 1987 amendments to the Clean Water Act formally established the National Estuary Program (NEP), and identified six "estuaries of national significance," including Narragansett Bay, that appeared to be threatened by pollution, overdevelopment or overuse. The goal of the NEP, which is administered by the United States Environmental Protection Agency (EPA), is to protect and improve estuarine water quality and habitat in order to support balanced and diverse marine resources, and to restore water quality-dependent uses of the estuary. Specifically, Section 320 of the federal Clean Water Act of 1987 directs participants in the NEP to convene Management Conferences to develop "Comprehensive Conservation and Management Plans" in order to "...recommend priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical and biological integrity of the estuary, including restoration and maintenance of water quality, a balanced indigenous population of shellfish, fish and wildlife, and recreational activities in the estuary, and assure that the designated uses of the estuary are protected."

The Narragansett Bay Project (NBP) was established in 1985 under the joint sponsorship of the EPA and the Rhode Island Department of Environmental Management (RIDEM). A Narragansett Bay Management Conference was formally convened for the purpose of preparing a Narragansett Bay *Comprehensive Conservation and Management Plan (CCMP)* when Narragansett Bay was officially designated an "estuary of national significance" on March 11, 1988. The NBP's mandate is to develop a comprehensive management plan for restoring, protecting and managing Narragansett

Bay's natural resources based on a thorough evaluation of the Bay's water quality, natural resource and use-related problems. The NBP has received over \$10 million since 1985 from federal appropriations provided under the federal Clean Water Act and matching funds provided by the State of Rhode Island.

01-01 The Need for a Comprehensive Conservation and Management Plan

In 1985, citing its concern for the "health and ecological integrity" of the nation's estuaries and estuarine resources, the United States Congress identified Narragansett Bay as one of four urban estuaries, nationwide, that required prompt, coordinated government action to reverse a trend toward deteriorating water quality, gradual loss of natural resources and increasing impairment of water quality-dependent uses of the estuary, such as shellfish harvesting. The NBP was subsequently established to administer a five year study of the Bay and its resources.

Public opinion surveys and goal-setting workshops conducted by the NBP in 1986 and early 1987 confirmed that many Rhode Islanders shared Congress' perception that Narragansett Bay was in poor health and needed coordinated public action to restore and protect it for future generations. As a result, the NBP's mandate was explicitly broadened to require the development of a *CCMP* to restore and protect Narragansett Bay under the 1987 amendments to the federal Clean Water Act. The need for a comprehensive management plan that addresses the entire Narragansett Bay watershed is more completely documented in Section 715-02 ('State of the Bay') and Section 715-04 ('Issues and Strategies'). [A list of commonly used abbreviations and acronyms is given in Appendix A.]

01-02 History of the Project

The NBP program office was established in 1985 under the joint sponsorship of the EPA and the RIDEM to develop a comprehensive strategy to address water quality and living

resource problems throughout the watershed, based on a directed study of the Bay and its resources. Through the process described in Section 01-04, the NBP identified seven issues that required additional study and possible corrective action:

1. Impacts of toxic pollutants;
2. Impacts of nutrients and eutrophication;
3. Land-based impacts on water quality;
4. Health and abundance of living resources and habitat;
5. Fisheries management;
6. Health risk to consumers of seafood; and
7. Recreational uses of Narragansett Bay. (Korch *et al.*, 1989:1)

Based on these seven issues of concern, the NBP, with the advice and approval of the NBP's governing committees (See Section 01-03), then began a comprehensive and integrated course of scientific study to describe the geographic distribution, magnitude and source(s) of environmental, public health and use-related problems facing Narragansett Bay. Over 110 scientific and policy-related studies were funded by the NBP between 1985 and 1991, several of them in cooperation with other federal and state agencies with jurisdiction in the Narragansett Bay watershed. These studies provided the basis for further policy development and specific recommendations for corrective action.

Under the 1987 amendments to the Clean Water Act, the NBP was nominated for inclusion in EPA's National Estuary Program. On March 11, 1988, Mr. Lee Thomas, Administrator of the EPA, and Rhode Island Governor Edward D. DiPrete signed a 'designation agreement' that officially recognized Narragansett Bay as "an estuary of national significance," included the NBP as a member of the National Estuary Program, and committed the EPA and the State of Rhode Island to developing an implementable *Comprehensive Conservation and*

Management Plan (CCMP) for Narragansett Bay.

The NBP continued to conduct scientific and policy-related surveys of the Bay and Bay basin following the 'designation agreement'. However, the Project also began to emphasize implementation of corrective actions. For example, the NBP:

- 1) established demonstration projects in the areas of nonpoint source pollution control ('Land Management Project'), toxic pollutant use reduction ('Hazardous Waste Reduction Project') and coordination of citizens' monitoring programs ('Citizens' Monitoring Project');
- 2) developed a Narragansett Bay Data System for the archival and analysis of long-term monitoring data;
- 3) developed planning tools for state and local resource managers such as a watershed-based pollutant loading model, technical guidance for delineation of buffer strips, and a mapped inventory of key coastal and subtidal habitats and species;
- 4) successfully competed for additional funds to develop a preliminary basin plan for Greenwich Bay, collect information to support basin planning efforts in Mount Hope Bay and the Blackstone River, and design and construct storm runoff controls on Interstate Highway 95;
- 5) participated on various state commissions involved with drafting legislation and/or developing statewide policy in the areas of water conservation, septage management, regionalization of municipal wastewater treatment facilities, protection of critical areas, and distribution of Aqua Fund bond funds for remediation of identified problems in Narragansett Bay; and
- 6) focused its public outreach program on implementation strategies for correcting identified environmental problems.

01-03 Project Governance

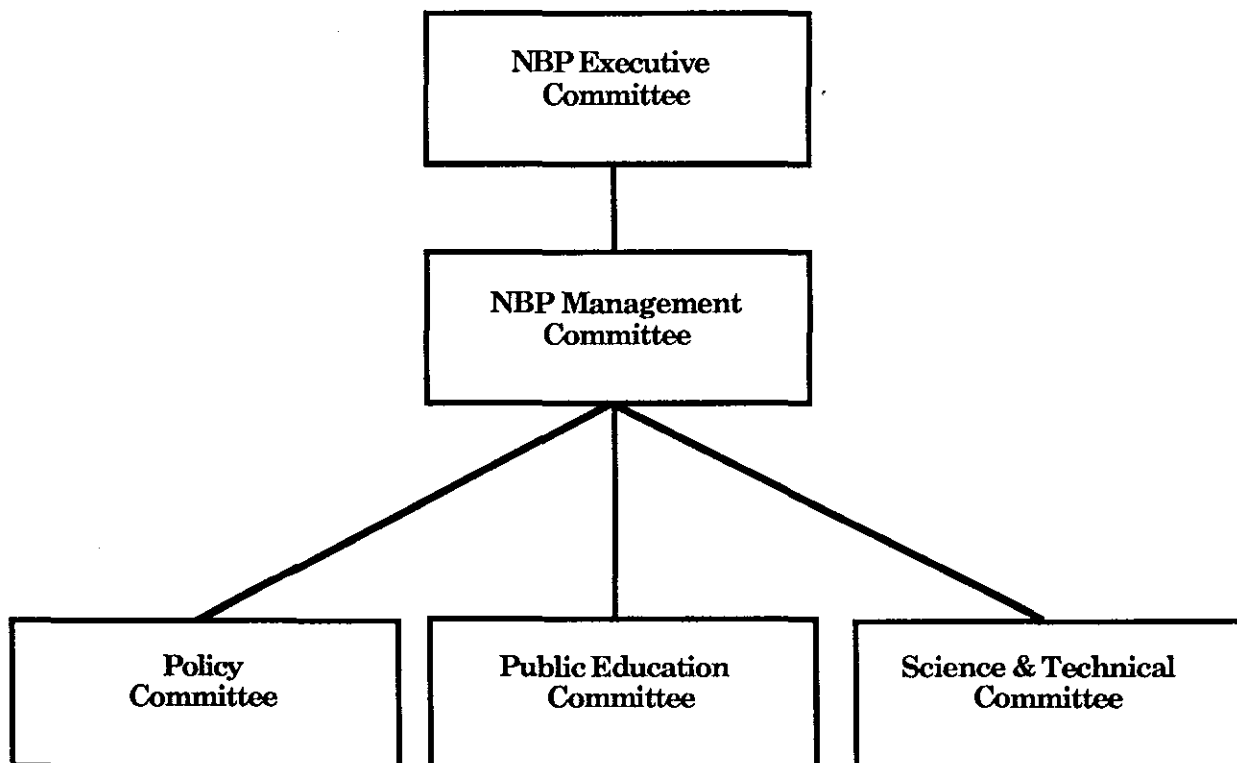
All activities of the NBP were governed by a hierarchy of advisory committees [Figure 715-01(1)]. The NBP Executive Committee, comprised of the Regional Administrator of the EPA Region I and the Director of the RIDEM, exercised ultimate decision-making authority regarding NBP policy direction between 1985 and 1990. In early 1990, the Executive Committee was expanded to include the Associate Director of the Rhode Island Division of Planning (RIDOP) and the Chair of the Rhode Island Coastal Resources Management Council (CRMC) as the NBP began to develop interagency agreements about implementation of the *CCMP*.

The NBP Management Committee was established in 1985 as the Project's primary decision-making body. The Committee provided broad representation to a diverse group

of managers and users of Narragansett Bay in the interest of achieving the broadest possible consensus about the Narragansett Bay *CCMP*. Federal, state, and local officials from Rhode Island and Massachusetts as well as representatives from marine, land development and metals industry trade organizations; environmental and commercial fishing organizations; and academia were represented at the invitation of the Executive Committee. Since 60% of the Bay watershed lies in Massachusetts, Massachusetts representation on the Management Committee was crucial to the development of *CCMP* recommendations and the orchestration of subsequent implementation activities. [A complete list of NBP Management Committee members is given in Appendix B.] The more than 100 professionals who served on the Management Committee between 1985 and 1992 donated their time, energy, and ideas to help oversee all phases of the development of the *CCMP* from design

Figure 715-01 (1).

Structure of Narragansett Bay Project Advisory Committees



of the research program through completion of the final *CCMP*. The Management Committee, which reported to the Executive Committee, also established subcommittees to advise Project staff and the Management Committee on specialized issues in different areas of expertise. Standing NBP subcommittees included the Policy, Public Education, and Science and Technical Advisory Committees. A technical staff housed within the RIDEM administered the daily activities of the Project and reported to the Management Committee. [A complete list of NBP subcommittee members is provided in Appendix B. A complete list of NBP staff is presented in Appendix B.]

01-04 Process of Plan Development

At the heart of the Narragansett Bay Project was an extensive research effort to objectively identify environmental problems and trends in the Bay and Bay watershed. This was coupled with a deliberate effort to reach common agreement about goals for Narragansett Bay and an open planning process. Public opportunities to participate in the planning process included conferences and "roundtable" discussions, a review of *CCMP* research and recommendations by the broadly representative NBP Management Committee and relevant Bay constituencies; a series of public information meetings on the draft *CCMP*, in association with a 101-day public comment period, and a formal public hearing conducted by the Rhode Island State Planning Council (Korch *et al.*, 1989:1).

The *CCMP* planning process involved four major steps which are described in more detail below:

- 1) Research and (early) implementation projects;
- 2) Public participation;
- 3) Planning and preliminary review; and
- 4) *CCMP* review and approval.

(A schematic illustrating the entire *CCMP* development process from research through

the adoption of the *CCMP* is shown in Figure 715-01(2).)

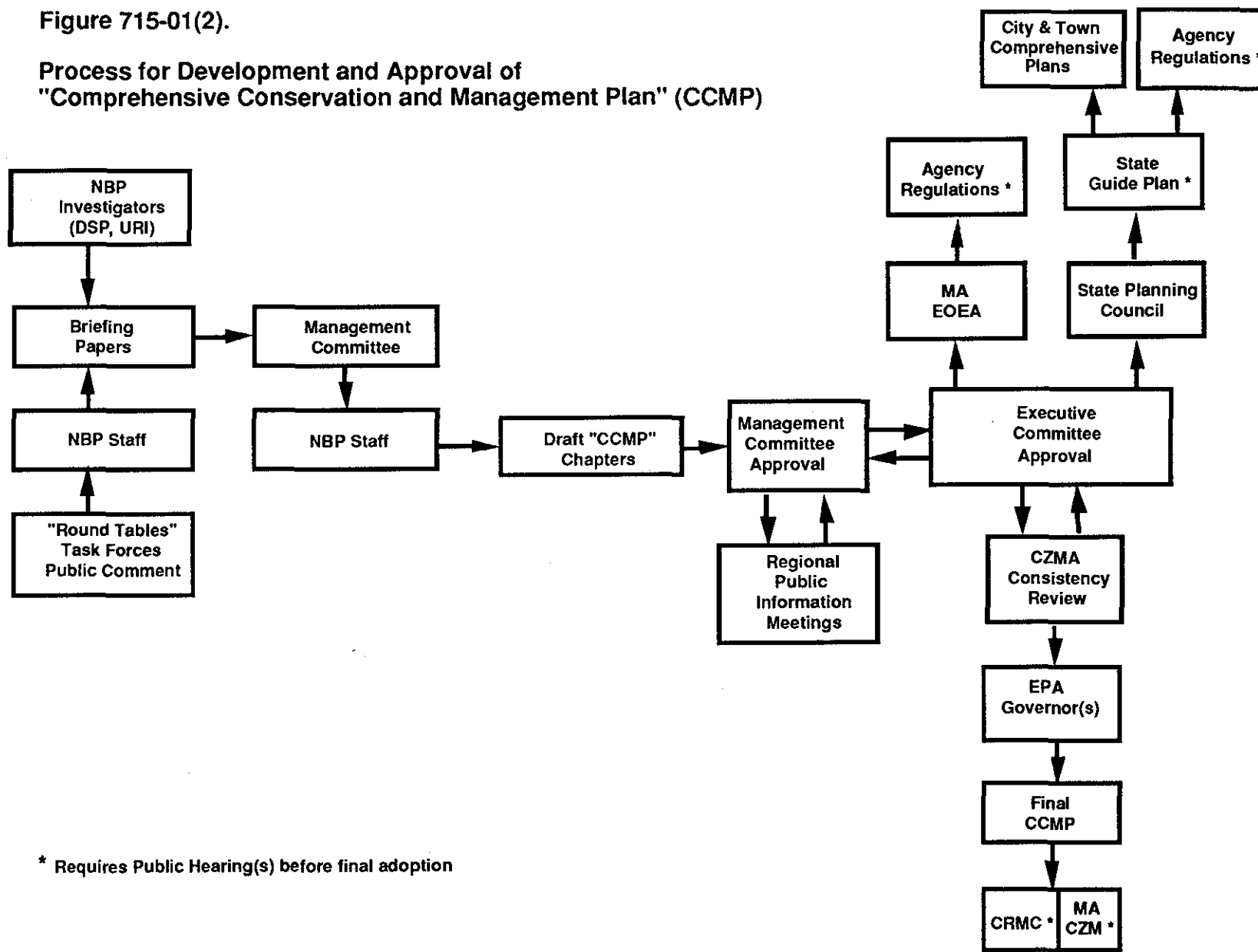
01-04-01 Research and (Early) Implementation Projects

The Narragansett Bay Project funded over 110 scientific and policy-related research projects from 1985 to 1991 in order to systematically examine the major issues of concern identified by the Management Committee and the general public. [See Section 01-04-02 regarding the NBP's process for identifying issues of concern and preliminary goals for restoring and protecting Narragansett Bay.] Research was conducted in the following areas: water and sediment quality, water quality modeling, land-use impacts on environmental quality, health and abundance of living resources and critical habitats, environmental policy and institutional analysis, and economics and public finance. [A bibliography of approved NBP research reports is given in Appendix C.] Approximately 75 percent of the NBP's entire budget went to supporting this research effort between 1985 and 1990. The remainder of the NBP budget went to program administration, public education, data management and supporting demonstration projects or "action plans". Beginning in 1990, the majority of NBP funds were used for development of the *CCMP*.

The NBP's research activities were planned by the NBP Science and Technical Advisory Subcommittee and the NBP staff, subject to Management Committee approval. Early studies focused on Bay-wide water quality trends and point source pollutant inputs. Later studies gradually narrowed to focus on specific geographic regions, pollution sources originating elsewhere in the watershed, and specific environmental problems and solutions. Every study was subject to extensive peer review and revision by the authors prior to publication. In addition, investigators were required to submit all original data for permanent archival in the Narragansett Bay Data System and/or the Rhode Island Geographic Information System (RIGIS). Copies of published technical reports were distributed to selected Rhode

Figure 715-01(2).

Process for Development and Approval of
"Comprehensive Conservation and Management Plan" (CCMP)



* Requires Public Hearing(s) before final adoption

Island state depository libraries and major Rhode Island academic institutions. In 1988, the NBP received additional federal grant funds from the EPA to establish demonstration projects or "action plans". These demonstration projects were developed as pioneering efforts to begin implementation of eventual CCMP recommendations. The Hazardous Waste Reduction Project (HWRP) and the Land Management Project (LMP) were established in 1988; the Citizens' Monitoring Project (CMP) was started in 1990. The NBP also collaborated with various federal, state and local agencies during the CCMP-development process to secure funds to start implementation of some elements of the CCMP, and draft necessary legislation. These efforts are briefly described below.

The HWRP was designed to assist Rhode Island industries in reducing the use and disposal of toxic chemicals. The HWRP has since been incorporated into the RIDEM's Office of Environmental Coordination and has won several national and international awards for its pioneering efforts in working with area industries, universities and agencies to demonstrate the economic and environmental benefits of source reduction.

The LMP was developed to assist Rhode Island cities and towns in managing growth and development to control nonpoint sources of pollution. LMP staff also worked with state agencies to provide technical assistance to Rhode Island cities and towns during the development of local comprehensive land use plans. The LMP worked with municipalities and the development community to document 'best management practices' (BMPs) and test educational materials such as model growth management ordinances.

The CMP was established in 1990 to act as a liaison between citizens' monitoring groups and state water quality regulators. The CMP focused its early efforts on persuading state officials to use citizen-generated data in the *State of the State's Waters (305(b))* water quality planning report, and to identify water quality problems requiring possible regulatory action. The CMP was also instrumental in expanding the existing net-

work of citizens' monitoring programs to include coastal waters.

The NBP also worked closely with various federal, state and local agencies during the CCMP planning process to begin early implementation of CCMP initiatives, where possible. In some cases, the NBP worked with other agencies to develop additional scientific information needed in order to begin implementation of the CCMP. For example, the NBP cooperated with the Massachusetts Coastal Zone Management Agency (MACZM) and the Rhode Island Coastal Resources Management Council (CRMC) to secure funds for water quality surveys in the tidal portion of the Taunton River to support future basin-planning efforts. The NBP worked with the EPA, the RIDEM and the Massachusetts Department of Environmental Protection (MADEP) in 1991 to perform river-wide water quality surveys of the Blackstone River to support future wasteload allocations for metals and nutrients.

The NBP also initiated or assisted with actual implementation of CCMP recommendations. For example, in 1990, the NBP was awarded a grant from the Rhode Island Aqua Fund Council to develop a preliminary basin plan for Greenwich Bay, and subsequently negotiated an interagency agreement between the RIDEM and the CRMC for completion of the basin plan. The NBP also worked with *Green Rhode Island* to develop draft legislation on mandatory water conservation; with the Governor's Blackstone Valley District Commission/Narragansett Bay Commission Study Committee on Regionalization to develop recommendations regarding the merger of two Rhode Island wastewater treatment authorities; and with the RIDEM to develop legislation on regulation of vessel discharges and designation of "no discharge areas". All three bills were passed by the Rhode Island General Assembly in 1991. NBP staff also drafted legislation for submittal in the 1992 or 1993 legislative session to require Rhode Island municipalities to establish wastewater management districts' to manage septage wastes generated by on-site sewage disposal systems. NBP staff are also working with the Rhode Island Association of Realtors to draft a

"seller disclosure" law to require property owners to report the status of on-site sewage disposal systems to prospective buyers.

01-04-02 Public Participation

From the Project's inception, the Management Committee and NBP staff conducted an open and accessible planning process to help draft a comprehensive plan that was principled, but also realistic and achievable. The Bay Project routinely sought advice from Bay user groups, including fishermen, quahoggers, boaters and industry trade organizations, as well as from environmentalists, scientists, developers, planners and government regulators. Representatives from these and other groups also participated in NBP-sponsored environmental review panels and public outreach programs, and on the Management Committee itself (Korch *et al.*, 1989:3).

There were three overall goals of the NBP's public outreach/education program in conformance with the mandate of the National Estuary Program. The NBP's first major public outreach initiative was to develop common agreements about issues of concern and goals for restoring and protecting Narragansett Bay. The NBP commissioned a public opinion survey in 1986 and a series of goal-setting workshops in 1987 in order to determine whether common agreements existed regarding goals for restoring and protecting Narragansett Bay. The results of these efforts were used by the NBP Management Committee to prioritize Project goals and define the scope of the Project's research and planning activities. The Project's goals were periodically reviewed by the Committee based on information from the studies and the NBP's on-going public outreach activities. The NBP conducted a follow-up public opinion survey in the fall of 1991 in order to determine whether the public's perception about Bay water quality, priorities for corrective action, or willingness to pay had changed since 1986.

The second major goal of the NBP's public participation program was to educate and inform the general public about the need for a comprehensive plan for Narragansett Bay.

With advice from the NBP Public Education Subcommittee, the NBP made a concerted effort to inform the public about the NBP planning effort and the Project's major research findings. For example, the NBP maintained a 5,000 person mailing list, an information hot-line, and an extensive publications file. The Project produced and distributed news releases, fact sheets (*Current Facts*), a series of newspaper articles (*Baywatch* and *Bay Action Plans*), a newsletter (*Currents*), annual progress reports, and videotaped and arranged the broadcast of panel discussions on major issues. The NBP staff also gave presentations at national, regional and local meetings and participated in public events such as Earth Day, the Rhode Island Boat Show, and the Providence Waterfront festival. These public education/public information efforts were conducted continuously from 1985 through adoption of the CCMP. [A list of the NBP's public outreach activities is presented in Appendix D.]

The third goal of the NBP's public participation program was to establish general agreement on realistic and achievable strategies and schedules for implementing the CCMP in order to assure that the implementing authorities performed their obligations as described in the Plan (Planners Collaborative, Inc. *et al.*, 1990). Roundtable discussions were conducted with government officials and representatives from the shellfish, metals and recreational boating industries; Blackstone River constituencies; and the land development community beginning in 1990. The roundtables were used to present scientific findings and preliminary recommendations to concerned constituencies, and to develop early agreements about CCMP implementation strategies. The NBP also worked with the staffs from other agencies, including the NBP's demonstration projects, to disseminate information about workable techniques for controlling pollution sources. For example, in 1990 the NBP, in cooperation with the Land Management Project, the RIDEM Nonpoint Source Pollution Management Program, and other organizations, co-sponsored *Designs for a Better Bay*, an awards program to recognize achievements in environmentally sensitive land use

design and development. This effort generated broad interest that resulted in similar design competitions in other estuary programs. In addition, the NBP, in cooperation with RIDEM's Ocean State Cleanup and Recycling Program, produced a wallet-sized *Clean Water Shopping Guide* to help people choose environmentally safe household products. Over 65,000 wallet guides were distributed with the assistance of New England Electric, the Narragansett Bay Commission, and other sewer and water authorities. The NBP also worked with Save The Bay and area communities to stencil storm drains tributary to the Bay with a "no dumping" warning. Finally, the NBP coordinated public review and comment on the draft *CCMP* following its release on January 10, 1992 (See Section 01-04-04). [See Appendix D, Part 1 for a list of NBP public outreach activities related to the draft *CCMP*.]

01-04-03 Planning and Preliminary Review

In mid-1990, following the substantial completion of the NBP's scientific investigations, the NBP Management Committee began to develop recommendations for abating identified problems in Narragansett Bay. Because of the scope and complexity of the available scientific information, the NBP staff prepared seventeen 'briefing papers' that summarized the relevant scientific information and proposed alternative strategies for addressing identified environmental, public health and/or use-related problems. The briefing papers were subject to technical review prior to distribution to the Committee for discussion. The Committee generally limited its review to discussion of controversial recommendations that one or more Committee members disagreed with and were unable to resolve with the staff. After review and approval, each briefing paper was published with minutes of the Management Committee meetings, summaries of decisions, and lists of Committee participants. [See Appendix C for a list of NBP publications, including briefing papers.] Recommendations approved by the Management Committee were forwarded to the Rhode Island Division of Planning (RIDOP) for incorporation into the *CCMP*.

The Management Committee began the process of prioritizing *CCMP* goals and strategies in 1991 after approximately half the briefing papers had been reviewed and preliminary cost and public finance information became available. In a series of facilitated discussions in June and November 1991, the Management Committee prioritized goals and objectives, agreed on which strategies would be expected to produce the greatest and most cost-effective environmental benefit over a five to ten year planning horizon, and identified 16 specific actions as the highest priority for implementation in the first two years after *CCMP* approval. Related recommendations were subsequently combined into the ten priority actions presented in the Executive Summary. Related high priority recommendations are also identified in each chapter (715-04, 715-05) with a checkmark and bolded text. The Committee's deliberations resulted in the draft *CCMP* which was subsequently distributed for public review and comment in January 1992.

01-04-04: *CCMP* Review and Approval

The NBP Management Committee conducted public review and comment on the draft *CCMP* in four phases. As the *CCMP* was being developed, the Project organized briefing sessions with targeted interest groups, government officials, and citizens throughout the Narragansett Bay area. In addition, between October 1991 and February 1992, Project staff presented the entire draft *CCMP* to the Technical Committee of the Rhode Island State Planning Council. These sessions were used to develop preliminary agreements about recommendations in the Plan. The NBP also conducted a major outreach effort to acquaint the general public with the Project's findings and solicit comment on proposed solutions.

The second phase of public review and comment commenced with the official release of the draft Narragansett Bay *CCMP* at a Rhode Island State House ceremony presided over by Governor Bruce Sundlun on January 10, 1992. A public notice announcing the release of the draft *CCMP*, the duration of the comment period, and the time and location of public information meetings, was published in

the Providence-Journal Bulletin newspaper on the same date. The original comment period extended from January 10, 1992 to March 2, 1992. In response to agency requests, the comment period was reopened for 30 days beginning on March 20, 1992. The extension of the comment period was also published in the Providence Journal-Bulletin, effectively resulting in a 101-day public comment period. [See Appendix D, Part 1 for a complete list of NBP public outreach activities related to the release of the draft CCMP for public comment.]

In association with the release of the draft CCMP, over 100 copies of the draft plan were distributed to NBP Committee members, the Rhode Island State Planning Council, municipal representatives and others. The draft CCMP was also distributed to thirteen public libraries in Rhode Island and Massachusetts. In addition, over 12,000 brochures and 2,200 CCMP "pocket summaries" were distributed to the Project's mailing list and interested members of the public at the beginning of the public comment period in order to promote interest in the public information meetings. The NBP also promoted the availability of the draft CCMP and the public information meetings through radio and television interviews and public service announcements, and a series of press releases and newspaper articles. Between February 11th and April 9th, the NBP conducted six formal public information meetings in Rhode Island and the Massachusetts portion of the Bay watershed. The purpose of the public information meetings was to present an overview of the draft CCMP and invite public comment. Over 150 people attended these meetings. In addition, Project staff made presentations on the draft CCMP to various special interest groups, state agencies and public officials. [See Appendix D, Part 1 for a complete list of NBP public outreach activities related to the release of the draft CCMP for public comment; and Appendix G for a transcript of public comments and proceedings of public information meetings.]

The third phase of the CCMP approval process involved compiling and responding to comments received on the draft CCMP.

Written comments were submitted by 38 individuals and organizations between January and May 1992. After Management Committee review and discussion of the staff's response to comments, the draft CCMP was revised and returned to the NBP Management and Executive Committees for approval. [See Appendix E for a summary list of commenting individuals and organizations; Appendix F for a summary of NBP response to comments; and Appendix G, Parts 1 through 4 for the full text of comments.] The revised final CCMP was then submitted to the EPA Administrator and the Governor of Rhode Island for approval.

The draft Plan was simultaneously presented to the Rhode Island State Planning Council for review as an element of the *Rhode Island State Guide Plan*. The public hearing scheduled by the Rhode Island Division of Planning as part of the State Planning Council's deliberations represented the fourth and final phase of the public review process. The notice of public hearing was published in the Providence Journal-Bulletin on May 28, 1992. The hearing, held on June 17, 1992, solicited public comment on the draft CCMP, including the NBP's *Response to Comments Received as of April 24, 1992* and the draft Narragansett Bay CCMP *Funding Strategy*. These comments were considered by the State Planning Council in making final revisions to the CCMP as an element of the *Rhode Island State Guide Plan*.

715-02 BACKGROUND: STATE OF THE BAY

Narragansett Bay is often referred to as "Rhode Island's most important resource." This statement acknowledges that the Bay and its associated watershed continue to supply the region with an abundance of seafood, secure transportation routes and sheltered harbors, and lovely places to live and play. However, Narragansett Bay and its tributaries are also "working" bodies of water because they are also relied upon to supply the region with energy, drinking water and a receptacle for receiving and diluting much of the region's industrial, commercial, and municipal wastes.

Like other urban and urbanizing estuaries, the health of Narragansett Bay has been compromised by some of these uses. However, in recent years, some of these threats have been abated or eliminated. For example, the U.S. Environmental Protection Agency (EPA) and the states of Rhode Island and Massachusetts have invested heavily in converting most of the region's wastewater treatment facilities to secondary treatment, resulting in improved water quality. In addition, many industries in the region have modified their manufacturing and disposal practices and have significantly reduced the discharge of toxic pollutants into the Bay and its tributaries. Many communities in the Bay watershed are also beginning to grapple with the environmental consequences of growth and development.

But other pressures continue to stress Narragansett Bay. Population growth and development throughout the region have increased pollutant loadings to suburban and rural as well as urban portions of the Bay. Fisheries stocks have declined, and sediments in some areas are severely contaminated. Environmental and public health problems related strictly to population growth are not likely to disappear, since population is expected to increase within the Narragansett Bay watershed, particularly in rural and coastal areas (RIDOA, 1989a).

Although there is evidence that water quality has improved in some areas of the Bay in

recent decades (see, for example, Karp *et al.*, 1990; Nixon, 1990, 1991; Metcalf & Eddy, Inc., 1991b; Penniman *et al.*, 1991a, 1991b), the pressures posed by projected population growth and development in the Bay basin must be addressed. Federal, state and local government must prepare for the projected growth in the region by protecting critical habitats. Although many point sources of pollution have been controlled, government must begin to regulate important nonpoint sources of pollution and the environmental consequences of growth and development. In addition to addressing current problems, the region also must attempt to prevent future problems from emerging. All levels of government and the public will have to act systematically and in concert to protect and restore this "estuary of national significance."

The purpose of "State of the Bay" is to summarize existing background knowledge about the environmental problems facing Narragansett Bay in order to establish the framework for the corrective actions recommended in Parts 715-04 (Issues, Objectives, and Strategies) and 715-05 (Implementation) of the *CCMP*. Based on information collected by the Narragansett Bay Project (NBP) and others between 1985 and 1991, this section describes the (1) physiographic setting of Narragansett Bay; (2) the history and current uses of the Bay; (3) pollutant sources, status, and trends; (4) living resources and critical habitats; (5) public health concerns; (6) governance by federal, state, and local authorities; and (7) priorities for action.

02-01 Physiographic Setting

Estuaries are semi-enclosed bodies of water, open to the sea. Within estuaries, seawater is diluted by the fresh waters carried by rivers and draining from coastal lands. Estuaries are productive biological regions, habitats, and breeding grounds for fish, shellfish, and many other organisms.

Narragansett Bay covers 147 square miles of water surface (Figure 715-02(1)). Its water-

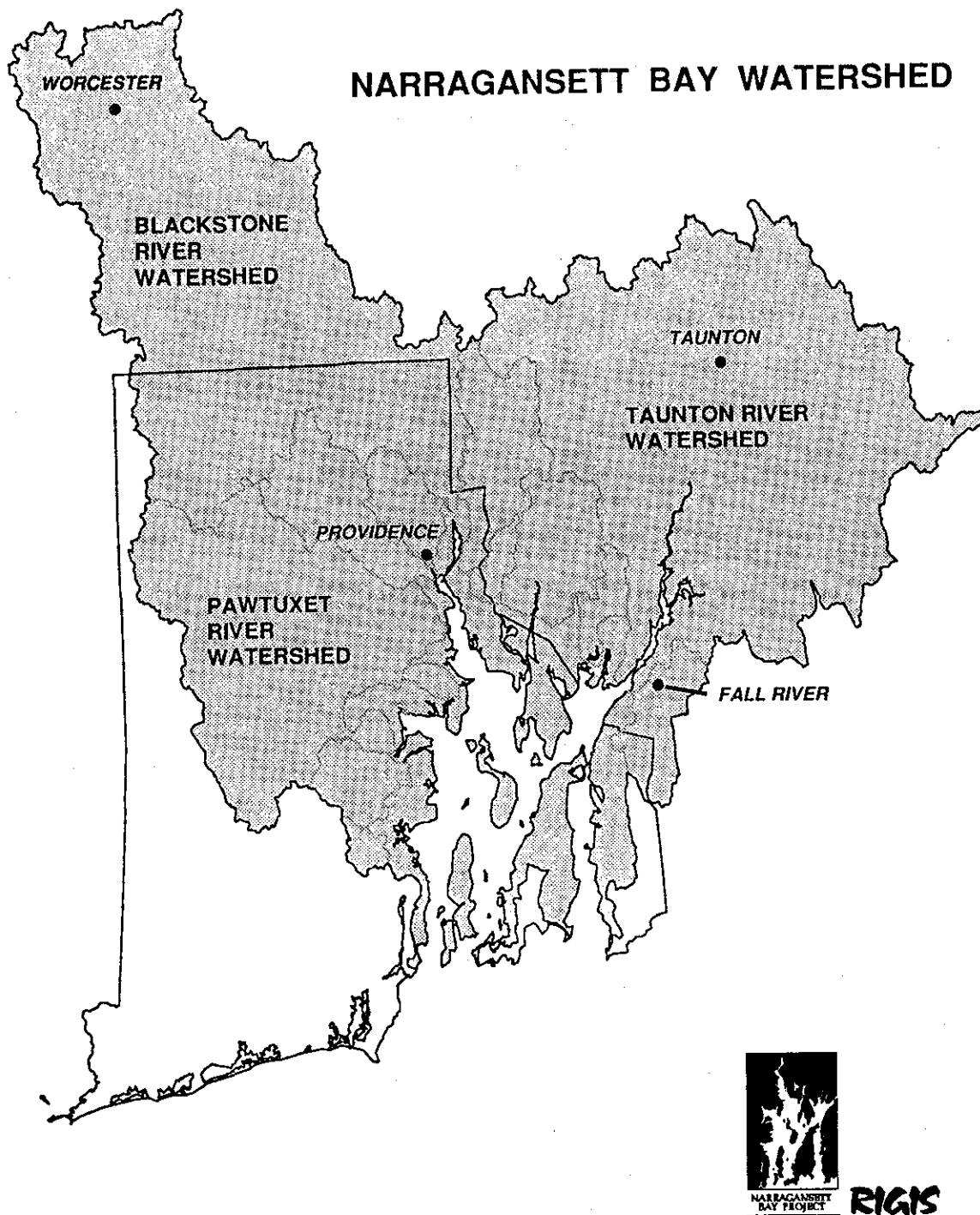


Figure 715-02 (1). Narragansett Bay watershed in Rhode Island and Massachusetts. (Map provided by NBP, RIGIS.)

shed comprises 1,657 square miles, 61 percent of which is in Massachusetts and 39 percent in Rhode Island. Major cities within the watershed include Worcester, Fall River, Taunton, and Brockton, Massachusetts; and Providence, Woonsocket, Cranston, Warwick, and Newport, Rhode Island.

When the last glaciers retreated northward from New England about 10,000 years ago, what is now Narragansett Bay was a series of streams and upland areas. The glaciers had reached as far south as the current Long Island, Block Island, and Martha's Vineyard. Those islands are all parts of terminal moraines, great mounds formed when the glaciers dropped the rocks, cobbles, gravel, and sand they had scraped off the New England landscape. Smaller moraines were formed farther inland, at points where the glaciers paused in their retreat. These moraines formed the low hills along the southern shore of Rhode Island.

As the glacial ice melted, sea level rose, flooding three river valleys and forming Narragansett Bay. Sea level continues to rise in the region, at a rate of about one foot each century. Some scientists believe that global warming could increase the rate of sea level rise to as much as eleven feet each century.

Narragansett Bay connects with Rhode Island Sound through the three ancient, drowned river valleys, the East and West Passages and the Sakonnet River (Figure 715-02(2)). East Passage is the deepest valley, averaging 50 feet (15.3 meters). In contrast, the average depth of the Bay is 27 feet (8.3 meters), and West Passage averages 25 feet (7.6 meters). East Passage provides deep water access for large vessels as far as Prudence Island, and dredged channels allow further passage to ports on the Providence and Taunton Rivers.

02-01-01 Freshwater Inputs

Total freshwater input to the Bay has been estimated to be approximately 2,400 million gallons per day (MGD) (Pilson, 1985; Ries, 1990). Most of the freshwater entering the

Bay, about 80 percent of the total flow, comes from Bay tributaries which are recharged by approximately 46 inches of annual precipitation (Ries, 1990; Pilson 1991). Other freshwater sources include direct precipitation on the Bay (310 MGD), wastewater treatment facilities (WWTFs) (248 MGD or 98 billion gallons per year), and combined sewer overflows (CSOs) (4 billion gallons per year). Groundwater and suburban stormdrains also contribute an unknown volume of freshwater. The Blackstone, Taunton, and Pawtuxet Rivers account for 63 percent of the total measured input of freshwater. Smaller rivers and streams, including the Woonasquatucket, Moshassuck, Ten Mile, Palmer, and Hunt Rivers account for the rest of the riverine flow, but do not contribute substantially to the total flow of water (Figure 715-02(3)) (Ries, 1990).

Water flowing from the rivers in the system is modified by dams and diversion of water from stream basins. Important flood control and water supply reservoirs within the watershed include the West Hill Dam Reservoir on the West River, near Uxbridge, Massachusetts, and the Scituate Reservoir on the North Branch of the Pawtuxet River. Water from the Taunton River is diverted to supply the City of New Bedford with drinking water. Water from the Nashua River watershed is used to supply the City of Worcester with drinking water, which is subsequently discharged to the Blackstone River as effluent from the Upper Blackstone Water Pollution Abatement District (UBWPAD) WWTF (Ries, 1990).

Direct precipitation onto the Bay surface accounts for approximately 13 percent of the freshwater input (the equivalent of 310 MGD) to the Bay. An additional 10 percent, about 248 MGD, comes from the 33 WWTFs, that discharge directly into the Bay or Bay tributaries (Karp *et al.*, 1990; Ries, 1990). Of this amount, approximately 52 percent is from Rhode Island facilities, and the remainder is from Massachusetts. The Narragansett Bay Commission's (NBC) Field's Point and Bucklin Point facilities, and the UBWPAD contribute the greatest volumes of wastewater. Total annual inputs of freshwater

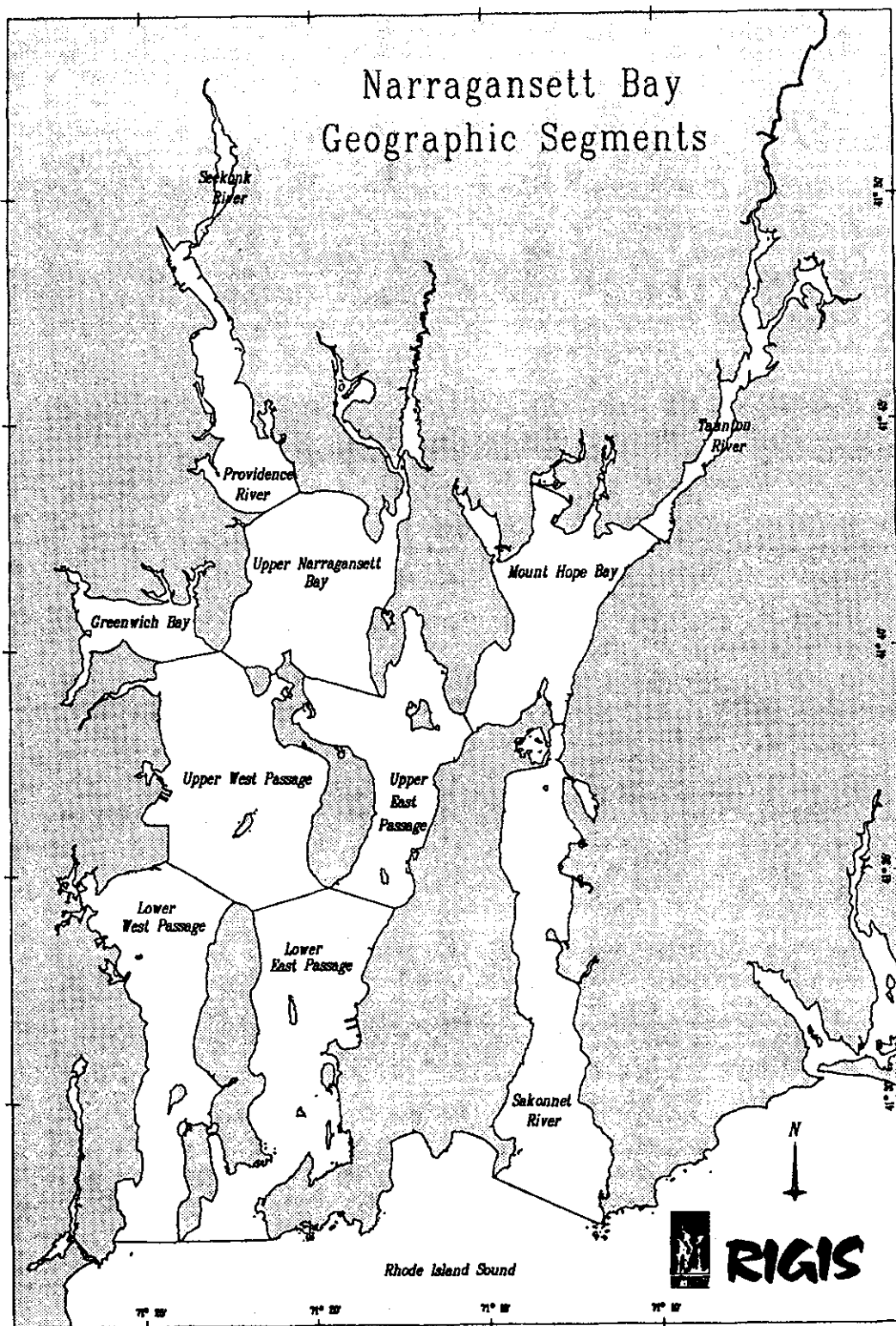


Figure 715-02 (2). Geographic segments of Narragansett Bay. (Map provided by NBP, RIGIS.)

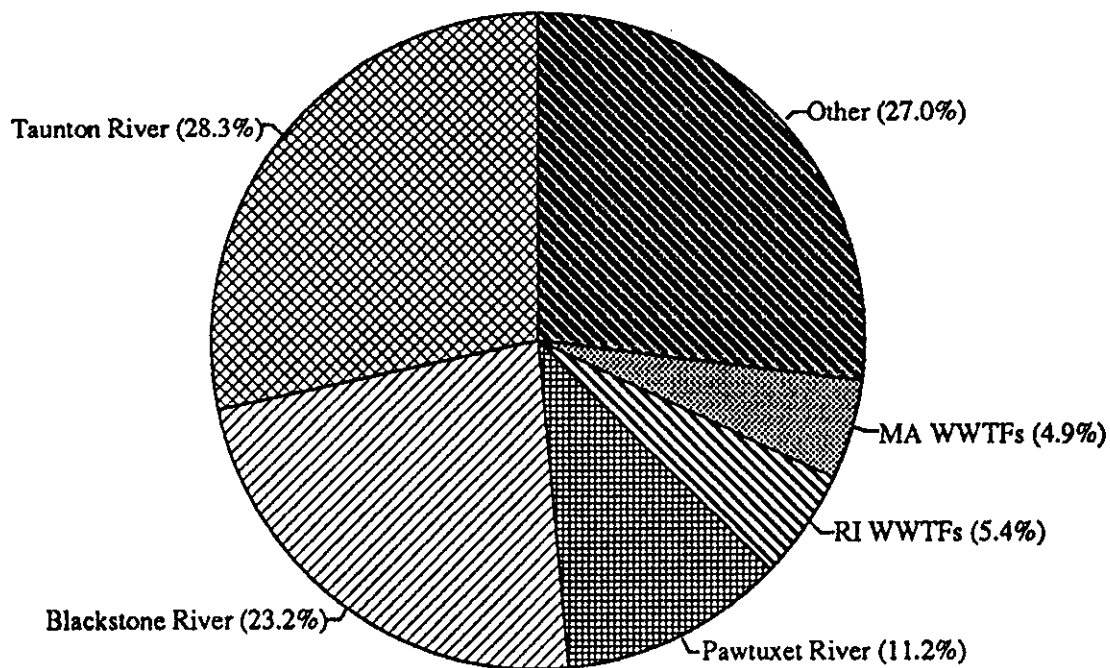


Figure 715-02 (3). Sources of freshwater to Narragansett Bay displayed as percentage of total annual freshwater input. (Data from Ries 1990 and Penniman *et al.*, 1991a.)

from CSOs (approximately 4 billion gallons per year) are small compared to inputs from the WWTFs (approximately 98 billion gallons per year), but during storms, they may contribute significant amounts of water (Metcalf & Eddy, Inc., 1991b). Flow of groundwater directly into the Bay has not been measured.

02-01-02 Circulation

Circulation of water within the Bay is complex, but important to understand because these circulation patterns affect the distribution of sediments, nutrients, pollutants, and microscopic floating plants and animals in the Bay. Because most freshwater sources are at the head of the Bay, there is a salinity gradient, with fresher waters in the Upper Bay and saltier water in the Lower Bay.

Freshwater is less dense than saltwater. Therefore, freshwater from the rivers tends to float on top of the saltwater, gradually mixing as it moves seaward. The currents, produced by this seaward flow, called nontidal currents, move at speeds of less than one half knot. They are, in part, responsible for moving water out of the Bay and into Rhode Island Sound, a process that takes between ten and 40 days. The average residence time of a molecule of water in the Bay is 26 days (Pilson, 1985).

Although the net movement of water in Narragansett Bay is downstream from the rivers to Rhode Island Sound, tidal currents also mix Bay waters. Tidal currents are the most important force mixing Bay waters and also help to move water in and out of the Bay. Tides are caused by the gravitational pull of the moon and the sun and the earth's rotation, and they cause the waters of the Bay to rise

and fall three to four feet every 12-and-a-half hours. Tides travel up the Bay like a wave, so high tide in Providence is about 20 minutes later than high tide in Newport. Tidal currents average one-and-a-half knots, and are even faster in certain areas.

Winds also play an important, although sporadic, role in circulation. During the summer, southwesterly winds dominate in the Bay. In the winter, most winds are northwesterly. Average wind speeds are highest in December and January, and result in accelerated movement of water out of the estuary and into Rhode Island Sound.

02-01-03 Sediments and Coastal Features

The glacial deposits of Narragansett Bay are overlain by a layer of material that has washed down into the Bay from its rivers. Rivers and the erosion of coastal bluffs provide most sedimentary material to the Bay. In general, there are finer-grained materials in the Upper Bay than there are at the mouth (Figure 715-02(4)) (McMaster, 1960; French *et al.*, 1992). The Providence River and protected harbors and coves of the Bay also contain finer-grained sediments. Areas with fine-grained sediments are likely sinks for particle-associated toxic pollutants in the Bay.

The cobble shores along most of Narragansett Bay are a reminder of the glacial deposits that helped form the area. The most common type of shoreline found around the Bay is a narrow beach of gravel and cobble that backs up to a scarp or bluff composed of glacial till. Sandy beaches are found along the ocean shores at the mouth of the Bay and in a few areas such as Conanicut Point in the Bay's interior. Rocky shorelines are found at Beavertail, Common Fence, and Brenton points. In protected areas where sediments accumulate, salt marshes fringe the shoreline (McMaster, 1960; French *et al.*, 1992).

Another important shoreline feature are the manmade structures that line approximately 25 percent of the shore. These structures include bulkheads or seawalls that were designed to prevent erosion. However, most coastal erosion in the Bay results from major

storms, such as hurricanes. Sometimes these structures actually hasten erosion by concentrating the wave energy in the area of the barrier.

02-02 History and Uses of the Bay

The oldest signs of human habitation in the Narragansett Bay area are about 3,300 years old. These remains were discovered on Conanicut Island. Europeans may have come to the area as early as Viking times, and Narragansett Bay may have been visited by the Englishman John Cabot in 1498. However, the first confirmed exploration of the Bay was by Giovanni da Verrazano in the ship *Dauphine* in 1524.

In 1635, Roger Williams, banished from the Massachusetts Bay Colony for his zealous desire to reform its church, landed by canoe on a peninsula called "Mooshassuc," a point where the City of Providence now stands. He was welcomed by the local Indians, who according to legend invited him to dine upon succotash and boiled bass. In 1644 Roger Williams obtained an official charter, incorporating the "Providence Plantations In Narragansett Bay."

The history of Narragansett Bay is one of rapid and intense population growth, accompanied by changes in land use, industrialization, and increased use of the Bay. The many and varied commercial uses of Narragansett Bay (Table 715-02(1)) contribute to the economic value of the Bay to the State of Rhode Island and the region. However, these uses sometimes conflict resulting in the degradation of Bay resources, and consequently impairment of water quality dependent uses of the Bay.

02-02-01 Population Growth

At the beginning of the 1800s, the rate of population growth was greater in Rhode Island than in any other New England state. Today, partially as a result of the industries that have prospered in the region, 1.8 million people live within the Narragansett Bay watershed, about half in Massachusetts and half in Rhode Island (Figure 715-02(5)). The area is densely populated, with 1,109

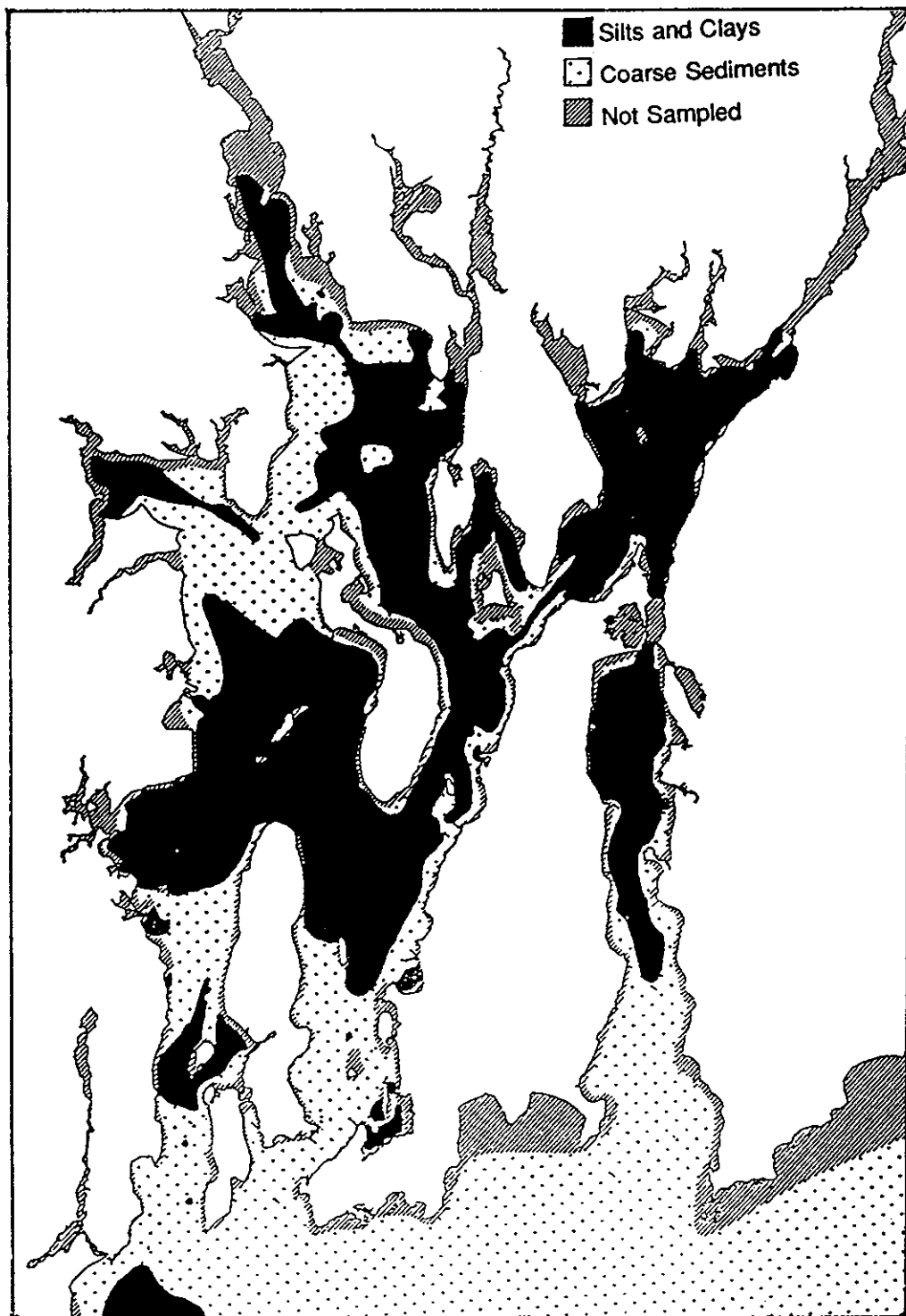


Figure 715-02 (4). Distribution of sediments in Narragansett Bay. (Data from McMaster, 1960.)

Table 715-02 (1). Estimated annual revenues associated with Narragansett Bay.
(Data are from Rorholm and Farrell, 1992, and are in thousands of 1982-1984 dollars.)

SOURCE	1967	1979	1989
Navy, except education	646,132	103,004	383,123
Marine Education, R & D	106,919	251,891	220,759
Marine Transportation	144,234	199,927	140,968
Bridges	3,257	6,335	8,631
Commercial Fishing	6,611	34,444	42,308
Marine Industry	179,659	518,821	637,365
Marine Recreation	78,766	121,975	146,761
Waste Disposal	21,557	21,664	31,111
TOTAL	1,187,135	1,258,061	1,611,026

people per square mile. In comparison, the nearby Buzzards Bay watershed in Massachusetts has only 613 people per square mile (NOAA, 1990).

Although Providence, Fall River, Worcester, and Brockton remain the most populated areas in the Narragansett Bay watershed, population growth is now greater in the suburban and rural areas. From 1960-90, population in Rhode Island's cities actually decreased by an average of four percent, while it almost doubled in the average town (RIDOA, 1989a). Although population growth has slowed in recent years, it is expected to continue well into the twenty-first century, with statewide growth of 9.5 percent projected over the years 1985-2010. Population growth is expected to continue to be greatest in the coastal and rural towns of the watershed (RIDOA, 1989a).

02-02-02 Changes in Land Use

As the population of Rhode Island has grown, the look of its landscape has also changed. Native Americans cultivated some of the land before the arrival of European settlers. During colonial times, about 75 percent of the state was cleared for agriculture. By 1935, however, about a third of this cleared land was no longer cultivated, and forests grew back from fields (RIDOA, 1989a). Since then, much of the area has become urbanized, and now about 36 percent of the total land area of Rhode Island is developed, seven percent is agricultural, and with the remainder forest, wetlands, and "open space" (Dixon *et al.*, 1991; RIGIS, 1991).

The number of housing units in the Narragansett Bay watershed has grown even faster than its population (Figure 715-02(6)). In Rhode Island's cities, the average number

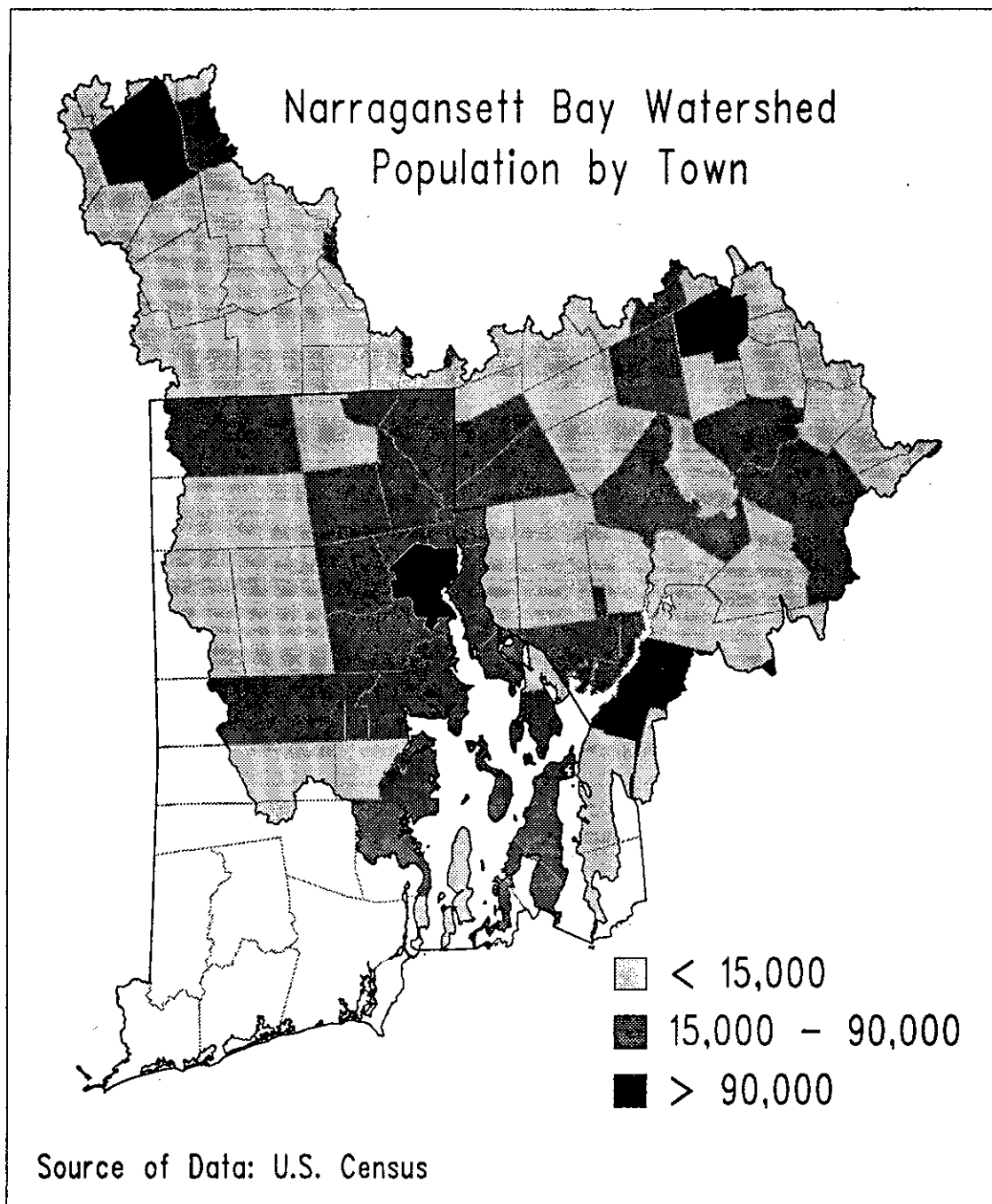


Figure 715-02 (5). Narragansett Bay watershed population by municipality according to the 1980 census. (Map from NBP, RIGIS.)

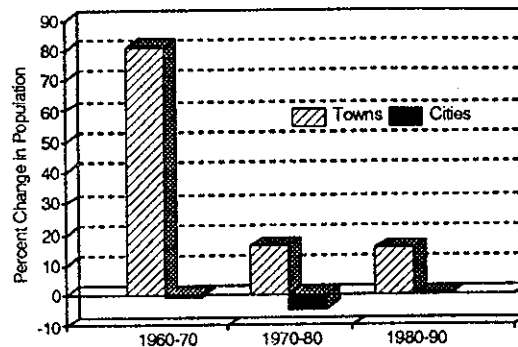
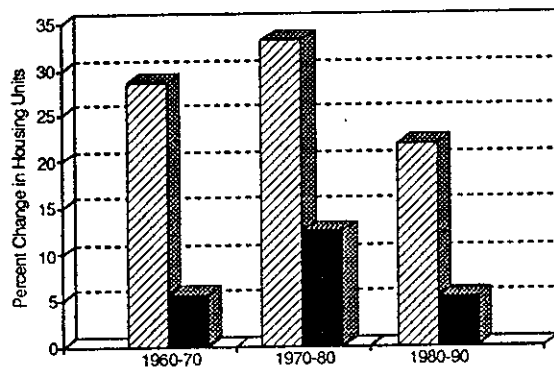


Figure 715-02 (6). Changes in population and number of housing units in Narragansett Bay cities and towns over 1960 to 1990. (Data from NBP.)

of housing units increased by an average of 27 percent during 1960-1990. In the towns, the average number of houses more than doubled during the same period. Similar to other areas of the country, the average size of a household has declined substantially since 1970. During the same period, average sizes of house lots have grown, spreading development farther into once-rural areas of the watershed. Growth is expected to be slower in the 1990s than it was in the 1980s, but increased pressures are expected to continue in rural and coastal communities (RIDOA, 1989a).

02-02-03 Ships, Shipping, and the Navy

Even before Rhode Island became a colony, Dutch settlers had established trading posts along Narragansett Bay. Shipyards were active by 1646, and the shipping trades of Newport and Providence prospered. During colonial days, shipping dominated the Rhode Island economy, largely due to the lucrative rum/slave trade.

During the 1830s, the economic influence in Rhode Island shifted from shipping to textile manufacturing. Although, shipping remained an important means for importing raw materials to the region and exporting

textiles, shipbuilding declined substantially. Today, most shipping in the Narragansett Bay region consists of petroleum, automobile, and lumber imports. Oil imports reached a peak in 1973, just before the Arab oil embargo plunged New England into a period of oil and gas shortages.

Beginning in 1979, investments were made to bring container ships to Rhode Island, opening the state to nonpetroleum imports. Relatively few goods are now exported from Rhode Island by ship or barge. However, in Rhode Island in 1987 more than \$64 million were spent on buying boats and boat-related equipment. Marine transportation revenues have been estimated as \$171 million in 1989. Toll receipts at the bridges spanning the Bay totaled \$8 million in 1989. Marine industry, including ship and boat building, marine equipment, and production of fresh and frozen fish products accounted for \$679 million (Rorholm and Farrell, 1992).

A military presence has been important in Narragansett Bay since the Revolutionary War. Throughout most of the history of the United States, coastal forts were an important part of the defense of the nation. After World War I, such defenses became outmoded. However, the Navy maintained a strong

presence in Narragansett Bay which peaked in 1941 to 1946 during World War II. In 1973, the Navy substantially reduced its facilities in Narragansett Bay. However, Naval activities remain a significant part of the regional economy. The Navy is closing additional bases, some of which are potential EPA Superfund sites, because they are contaminated with toxic pollutants.

Wages and salaries for naval personnel, contracts and other procurements, and minor aid to local schools totaled \$383 million in 1989. Approximately 29 percent of that amount was spent on direct personnel payments, the remaining 71 percent on contracts. This value represents an increase over the preceding decade, although the total spent by the Navy is less than it once was.

The Navy, along with federal and state governments, also funds marine education and research and development. Approximately \$221 million in salaries, wages, supplies, and equipment was spent in naval education, federal laboratories in Narragansett, the University of Rhode Island's marine programs, and other state laboratories.

02-02-04 Industry

During the 1790s, Rhode Island became the center of the American Industrial Revolution. Samuel Slater's introduction of a primitive factory system to Moses Brown's textile mill in Pawtucket, Rhode Island, is often cited as the Industrial Revolution's beginning in the United States. The mill harnessed the energy of the Blackstone River to spin cotton into thread.

At first, the Industrial Revolution spread slowly, but with government needs for the War of 1812 and the inventions of the power loom and machinery to clean cotton, the Rhode Island cotton industry expanded dramatically. By 1860, both the woolen and the cotton industries were dominated by the factories that lined the shores of the Blackstone River.

With the growth of the textile industry came comparable growth in the production of machinery and machine tools. David

Wilkinson, who made the castings for Slater's first carding machines and later developed the power loom, also invented the American industrial lathe and was an early experimenter with steam power. In 1793, he cast and assembled a steam engine that powered a paddleboat on the Providence River. He installed a steam engine in his own mill in 1810.

The expansion and diversification of the Industrial Revolution were apparent throughout the Narragansett Bay watershed, but were concentrated in the upper portions of the Bay and along the major rivers. Metal industries were interspersed with the textile industry along the Blackstone and Pawtuxet rivers and in Providence. Farther up the Blackstone River, the City of Worcester, Massachusetts, became a center for manufacturing textile machinery.

With the outbreak of the Civil War, Rhode Island began to manufacture munitions for the Union Army and boilers for the Navy, in addition to textiles. The return of peace brought an even greater prosperity, when firms that had become established during the war diversified into the manufacture of locomotives, tools, and sewing machines.

Providence jewelers also prospered after the Civil War, overtaking cotton manufacturing as the city's leading industry in 1880. The precious metals industry had its beginnings in the late 1700s, when Seril Dodge began to manufacture silver buckles, and his brother Nehemiah Dodge opened a jewelry, clock-making, and goldsmith shop. By 1880, Providence could call itself the "jewelry capital of the world."

In the more than a century that has followed 1880, industry has become more diversified, and manufacturing has declined to a smaller share of the economy of the region. In 1990, 332,000 Rhode Islanders were employed in the service industries, while only 118,000 were employed in manufacturing.

02-02-05 Fishing

Fishing was undoubtedly important to the Native Americans who lived along Narragansett Bay's shores before the arrival of European colonists. Archaeological excavations on Conanicut and Block Islands show the importance of seafood in the region. Tales from colonial times paint pictures of a Narragansett Bay teeming with sea life, of lobsters that could be caught by hand at low tide, of vast schools of bluefish and cod, and of dense beds of oysters and clams.

Early colonists caught fish on hook and line or with small seines. During the second half of the 1800s, floating and staked traps blocked large parts of the Bay. Concern that these traps could decimate fish stocks led to strict restrictions on their use. During the 1930s, trawlers began to drag the bottom of the Bay for fish.

Oysters were once abundant in Narragansett Bay. In the early days, they were among the staples of the colonial diet. As in most East Coast states, production of cultivated oysters in leased beds peaked around 1910. By the 1930s, decreased oyster production could no longer meet the continued, stable local demand. Explanations for this decline have been many and varied. Overfishing was noted in East Greenwich, Rhode Island, as early as 1766, and legislation controlling harvests was very strict by the 1860s (Desbonnet and Lee, 1991). Predators and pollution have also been implicated in oyster declines. The 1954 hurricane dealt the final blow to the already weakened industry, killing an estimated 90 percent of the oysters. The last oyster dealer in Rhode Island went out of business in 1957 (Desbonnet and Lee, 1991). Since then, the cultivated oyster business has not recovered, possibly because of additional environmental degradation and coastal development, and competition from other oyster-growing areas. However, there is recent anecdotal evidence of recovery of oyster beds near East Providence, Prudence Island, and areas of Mount Hope Bay.

Native shad, alewife and Atlantic salmon fisheries were also historically important. All three species depended on Bay tributaries

for spawning. Dams, effluent from the textile and metal product industries, and sewage pollution almost eliminated shad from Narragansett Bay in the 1880s. Although shad populations remained small, catches peaked again in Rhode Island in the 1940s, a result of high fishing pressures during World War II. Subsequent catches fell rapidly, due to decreased demand and decreased availability, possibly due to overfishing. This brief period of high catches during the war was not a symptom of recovery of the fish but rather an artificial peak, produced by extreme demand and exploitation of the resource (Olsen and Stevenson, 1975). The alewife fishery was essentially gone by 1925. The salmon fishery had already collapsed by 1869, probably because there were no suitable upstream spawning grounds due to flow restrictions and/or water quality (USFWS, 1989).

Menhaden, which spawn within upper Narragansett Bay and Mount Hope Bay rather than upstream in freshwater have fared somewhat better than the shad, salmon, and alewives. Overfishing by fish traps caused the fishery to fail in the late 1800s. Since then, harvests have diminished (Oviatt, 1977). However, by weight, menhaden remains the largest commercial fishery in the Bay.

Today, the quahog, or hard clam, represents Narragansett Bay's primary commercial fishery. Other commercial fisheries include lobster, long-finned squid, scup, silver hake, squirrel hake, summer flounder, sand flounder, ocean pout, butterfish, and cod (Jeffries et al., 1989). There are also significant recreational fisheries for bluefish and tautog. Until recently, winter flounder supported economically important commercial and recreational fisheries. However, in 1991, because of concerns over drastic declines in abundance, largely due to overfishing, Rhode Island banned commercial and recreational fishing for winter flounder in Narragansett Bay, Little Narragansett Bay, and the coastal salt ponds.

Overfishing, habitat destruction and contamination by toxic pollutants represent ongoing threats to these resources. Total

landings of finfish declined from 72.5 million pounds in 1985 to 26.5 million pounds in 1989, with winter flounder accounting for 19 million pounds of the decrease (NOAA/NMFS, 1991). Total value of the finfish landings decreased from \$33.2 million to \$2.9 million during that period (NOAA/NMFS, 1991). Like the oyster and the shad, these fisheries also could be destroyed.

02-02-06 Recreation

Narragansett Bay's many small harbors and protected, sandy beaches contributed to its reputation as a recreation area. During the 1880s, Newport was perhaps the most affluent and extravagant resort area in the country. The extreme affluence ended with the 1929 stock market crash, and the 1938 hurricane destroyed many resorts along the Bay's southern shores. Beginning in the 1960s, however, family vacationing in the Narragansett Bay area began to boom, and this boom has continued.

Rhode Island residents and tourists today take part in sailing, world-renowned yachting regattas, music festivals, swimming, fishing, surfing, and picnicking. An estimated 32,000 people visit Rhode Island each day in the summer. Between 5 and 10 million tourists visit Rhode Island each year, primarily in the summer and primarily around the Bay. In 1989 more than \$1400 million was spent by tourists in Rhode Island, much of it on Bay-related activities.

Tourism is now the State of Rhode Island's third largest employer. The state operates 25 state parks, and there are many shoreline campgrounds and picnic areas. One hundred and seventy marinas dot the coastline; tourist services and outlet stores line the major and minor highways; and an increasing number of conventions brings tourists to the state throughout the year.

02-02-07 Use of the Bay for Waste Disposal

Despite the importance of tourism to the region's economy, some areas of the Upper Bay are closed to swimming, other water-contact sports, and shellfish harvesting.

These closures result entirely from pollution associated with population growth and urban-industrial development in near coastal areas. Municipal and industrial wastes and dredged materials have been disposed of in the Bay.

Human wastes have probably been discharged into the Bay as long as the area has been inhabited. In 1854, Providence was the seventh largest city in the United States. Most people used cesspools and privies, the contents of which were used as fertilizer or disposed of in landfills. The Moshassuck River, a branch of the Providence River, was used as an open sewer, and regular outbreaks of cholera claimed the lives of the people who dwelled along its shores. Population growth was enormous, and increasing quantities of sewage entered the river, along with wastes from slaughter houses and woolen mills.

A sewer system became a necessity for the City of Providence in 1871, when the city provided its residents with running water. Indoor toilets were connected to existing cesspools, and the increased volumes of water used in flushing overflowed the systems. Construction of a sewer system began immediately. That system discharged wastes directly into the rivers and the Bay.

In 1884, City Engineer Samuel M. Gray was dispatched to Europe to learn about the latest methods of treating sewage, and in 1901, the Providence Sewage Treatment System began operation at Field's Point. The system used chemicals to facilitate precipitation of sludge from the raw sewage. The sludge was then used as fertilizer, while the remaining effluent was discharged into the Bay (Nixon, 1990).

Within a decade of its opening, Providence had outgrown its sewage treatment system. The City began to barge the sludge and dump it into the Bay east of Prudence Island and about 14 miles south of the city. In addition, the chemical-precipitation method brought by Samuel Gray from Europe was proving an unsatisfactory sewage-treatment process.

In 1925, the Providence City Council visited eight cities throughout the United States to

learn about new sewage treatment methods. Conversion of the Field's Point facility to use an activated-sludge process was completed in 1934. Other improvements to the system were made in subsequent years.

By the 1970s, this system was again inadequate. The facility had become antiquated, an inadequately sized staff maintained it, and charges of political mismanagement were leveled at its directors. Raw sewage was regularly released into the Bay, and sewage solids were found on beaches. In 1980, a regional approach to managing the problems of sewage waste treatment was adopted with the creation of the Narragansett Bay Commission (NBC). With financial assistance from the EPA and the State of Rhode Island, the NBC has been able to reconstruct and upgrade the Field's Point facility.

The Bay also receives numerous discharges from the industries that flourish in the region. Today, 33 major industries in Massachusetts and Rhode Island continue to discharge directly into the watershed under federal National Pollutant Discharge Elimination System (NPDES) major permits or Rhode Island Pollutant Discharge Elimination System (RIPDES) permits. There are also numerous industrial and commercial discharges to sewer systems. These indirect discharges ultimately reach Narragansett Bay.

Sewage effluent and sludge are not the only materials that have been disposed of in Narragansett Bay. Because many parts of Narragansett Bay are shallow, regular dredging of channels and harbors has been conducted to maintain access for the small boats or large ships that use them. Materials dredged from the bottom were disposed of on salt marshes and other coastal lands until the 1960s. Many of Narragansett Bay's fringing salt marshes were filled to support coastal development.

Dredged material was also disposed in Narragansett Bay's deeper waters. Between 1949 and 1966, material was dumped off the southern end of Prudence Island, as well as at the Brenton Reef Disposal Area, near the mouth

of Narragansett Bay in Rhode Island Sound. Dredged material is no longer disposed within Narragansett Bay waters because no site has been designated in the Bay. Upland disposal still occurs, subject to receipt of permits from the Rhode Island Coastal Resources Management Council (CRMC), the Rhode Island Department of Environmental Management (RIDEM), and the U.S. Army Corps of Engineers (USACOE).

02-03 Pollutant Sources, Status, and Trends

02-03-01 Pollutant Sources and Water Quality

Three major classes of anthropogenic pollutants are discharged to Narragansett Bay and the Bay basin: fecal wastes, potentially including pathogenic bacteria and viruses; excess nutrients and oxygen-demanding organic matter; and toxic pollutants, including trace metals and organic compounds. Although these pollutants are generated by industrial, commercial and domestic activities throughout the Bay basin, they enter the Bay from myriad point and nonpoint sources.

Point sources, such as the discharge pipes for WWTFs and industrial facilities, are a major route for delivery of pollutants to the Bay. Each year approximately 98 billion gallons of treated wastewater enter the Bay from 33 WWTFs serving over one million people in Rhode Island and Massachusetts. In addition, each year over 100 CSOs in the basin discharge approximately four billion gallons of untreated sewage and stormwater to the Bay waters (Figure 715-02(7)). Direct industrial discharges also contribute to the pollutant load.

Nonpoint sources are more diffuse and difficult to quantify. Nonpoint sources of contaminants to the Bay include runoff from highways, parking lots, farmlands and lawns. Seepage from on-site sewage disposal systems; discharges by ships and boats; accidental chemical spills; and resuspension of contaminated sediments also represent locally important sources of contaminated deposition.